

How to Implement a Volunteer Water Quality Program

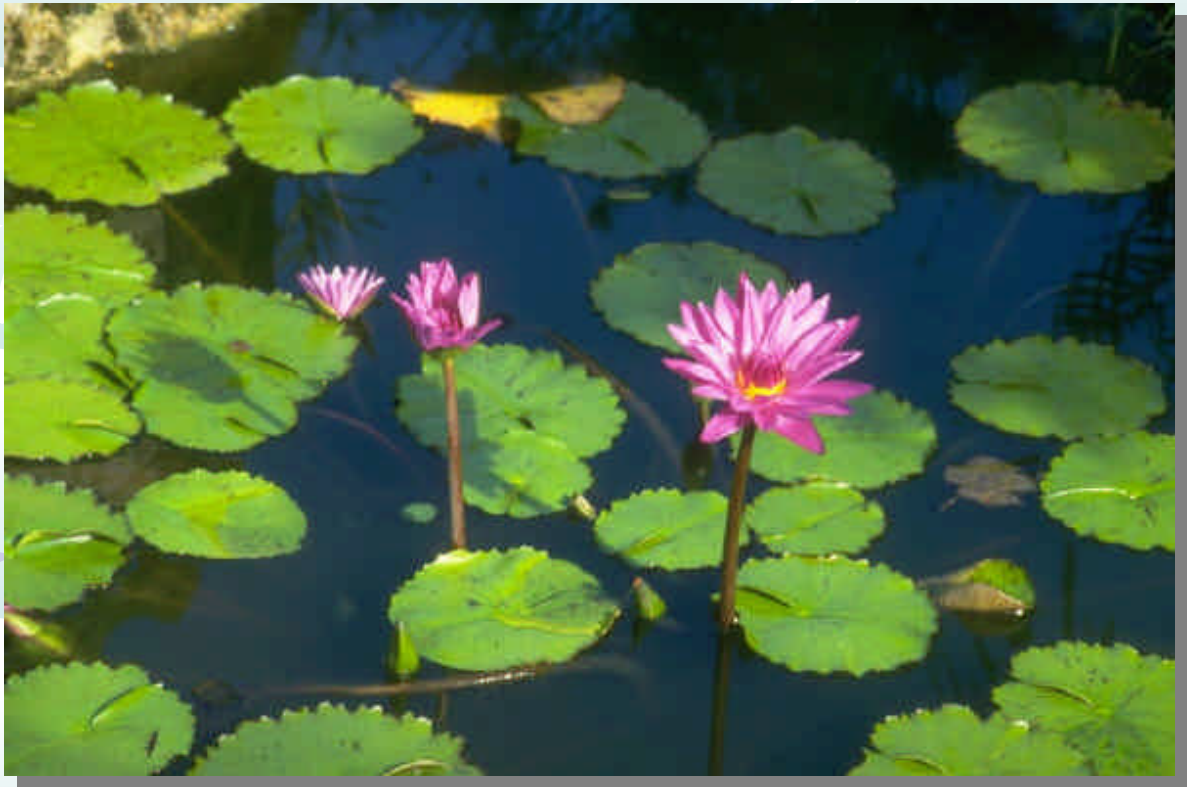


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INTRODUCTION

Implementing a volunteer water quality monitoring program takes careful consideration, dedicated staff members, time, and money. This manual is a step-by-step guide to creating and implementing a volunteer water quality program. It provides program options, sources of funding, assistance in quality assurance project planning, ideas for recruiting and retention, and methods of water quality monitoring that are successfully utilized today. The development of a volunteer water quality monitoring program is a detailed process, but is well worth the benefits that a successful program will bring.

THE BENEFITS OF VOLUNTEER WATER QUALITY MONITORING

Too often, volunteer programs are implemented to save money or replace paid positions. In reality, the benefits of a Volunteer Water Quality Monitoring program far exceed the cost of the program, but initially the program requires a solid commitment of resources. There are many benefits to establishing a volunteer water quality monitoring program.

- ✓ Involves the community in program goals
- ✓ Extends education beyond the program
- ✓ Fulfills monitoring objectives
- ✓ Identifies ambient water quality and trends
- ✓ Provides comprehensive water quality information
- ✓ Fills in gaps in statewide monitoring data
- ✓ Provides data for regulatory and land use decision-making

In addition to providing water quality data for your specific program needs, policymakers and regulating agencies need area wide data to determine pollution loading requirements and land use planning. Historically, agencies believed that only professional scientists using state-of-the-art equipment and the highest quality assurance measures could collect accurate enough data for decision-making purposes. Improvements in field monitoring equipment and procedures, comprehensive volunteer training programs, and laboratory test quality assurance methods have demonstrated that water quality data collected by volunteers can be just as accurate. Since the increased need for water quality data exceeds the availability of professional monitors and volunteer data has been demonstrated to be accurate, state and federal agencies are using volunteer data to make important regulatory decisions. For example, in the Perdido Basin area, along the Florida/Alabama border, volunteer data made up the majority of the data to help determine Total Maximum Daily Loads (TMDL) for the impaired waters rule. A TMDL is the maximum amount of a specific analyte that can be discharged into a water body on any given day. TMDLs are defined by the water body's ambient water quality and trends of water quality over time. Volunteer data are assisting state and federal agencies determine the TMDLs for water bodies throughout Florida and are substantially contributing to the data sets in areas that are underrepresented by professional water quality monitoring programs.

Perhaps the most important and most underestimated value of volunteer monitoring programs is the public involvement and avenues for community outreach that it provides. Volunteer water quality monitoring provides a hands-on approach to educating the public on water quality issues. Volunteer monitoring promotes citizen awareness, involvement, and environmental stewardship and provides the opportunity for volunteers to demonstrate to citizens that their daily actions have consequences that affect not only water quality, but also the environment as a whole. Furthermore, the lessons learned by volunteer monitors are often translated to their families and peers through normal daily interaction and conversation. Community stewardship, program support, advocacy, and education may be the greatest benefits of implementing a volunteer program.

THE BASIC WATER QUALITY MONITORING CONCEPT

Volunteer water quality monitors use instruments and proven methods to collect and analyze water for parameters that describe the overall health of the water body.

Water quality means different things to different people. A scientist or environmental professional may define water quality by ecosystem function or pollution levels, a fisherman may measure water quality by the health of fisheries, and a property owner may measure the aesthetic qualities of the water body. Although all three are assessing water quality, the only tangible way to consistently assess water quality is by measuring specific, predetermined, chemical and physical parameters using standard procedures. Volunteer water quality monitors use instruments and proven methods to collect and analyze water for parameters that describe the overall health of the water body. The major physical and chemical parameters available for monitoring by a volunteer group are described in detail further along in this manual; however, the purpose for monitoring them may need some explanation.



Ambient Water Quality Monitoring and Trends Analysis

Assessing the health of a water body through ambient water quality and trends analysis requires the consistent collection of accurate data over time. A single sampling event provides very little information about the health of a water body just as taking a person's temperature one time provides little information about their overall health because there are too many variables. Continued data collection provides information about ambient water quality in different conditions (i.e. rainy season, drought conditions, increased urbanization, etc...) as well as trends

in changing water quality. Data can determine whether actions to reduce pollution impacts are working or indicate that conditions are degrading. Many sampling scenarios over time provide ambient water quality conditions, show trends in water quality, and enable resource managers to evaluate overall water body health. The longer a volunteer program has been collecting data, the more useful the data are in assessing the health of the aquatic system.

Point Source and Nonpoint Source Pollution

Point source pollution is easy; it's the one everyone thinks about when they think about water pollution. Envision the big pipe leaving a factory with green-black ooze pumping out into a nice clean river. That's a point source. Fortunately, the National Pollution Discharge Elimination System (NPDES), administered by state environmental agencies or the United States Environmental Protection Agency (EPA), began controlling this type of pollution in the 1970's. Current law requires that any facility discharging to a water body must have a permit that ensures



the water quality will not be significantly degraded. Factories do this by using the best available technologies and best management practices to minimize pollution.

Nonpoint source pollution (NPS) is much more difficult to envision. It doesn't have a convenient pipe to point to or a factory to blame. Instead, it comes from diverse sources such as homes, lawns, parks, ball fields, streets, farms and even air pollutants in

the atmosphere! Basically, NPS pollution is water pollution that cannot be traced to its specific origin or starting point. Regardless of the source or type of NPS pollution there is a common link that's important to water quality monitoring. NPS pollutants are carried to your water body by water running over or through the ground each time it rains, the snowmelts, or when land surface is irrigated. Common NPS pollutants include such things as soil or dirt from construction sites, oils from streets or parking lots, grass clippings or yard debris dumped down a storm drain or fertilizers and pesticides washing off yards and parks. These are pollutants? You bet, and they're the toughest ones to control. It's easy to go to the factory and write a violation, it's much tougher to figure out whose yard is polluting a lake with fertilizer.

Since it is impossible to measure nonpoint source pollution at a single point, it is necessary to measure ambient water quality to assess overall impacts. Water quality monitoring provides the means to evaluate the impacts of nonpoint source pollution as well as point source, determine actions to reduce nonpoint source pollution loading and assess whether those actions are working.

About Stormwater Runoff and NPS

As the human population continues to grow, more land is developed from rural to urban or suburban. Although rural, urban and suburban land use all result in NPS pollution, there is a factor, which causes the more developed areas to have increased potential for contributing pollution. That factor is impermeable surface area such as asphalt, concrete, brick, stone, rooftops, or any other surface that does not allow water to soak into the ground. In a forest or farm, almost all the rain that falls has the opportunity to reach the earth and soak into the ground resulting in very little surface water runoff. As farms or forests are developed into neighborhoods, the amount of impervious surface greatly increases with the numbers of streets, houses, and shopping centers. Much more runoff occurs because there is less earth exposed for the water to soak into.

To prevent runoff from flooding our homes and businesses, drainage systems, detention ponds and other water management practices are constructed to transport the water to the nearest river or lake. With the runoff, NPS pollutants are also carried along, destined to degrade the water quality of the receiving body. As we develop our communities, the potential for NPS pollution and the need for water quality monitoring increase.



Safety

Throughout this manual you will find safety suggestions. Not every situation is anticipated nor can it be; safety relies largely on common sense. No water quality data are ever more valuable than an individual's safety. Volunteers need to be reminded that if for any reason their safety may be compromised by a chemical spill, lightning, fast moving water, traffic or whatever, they should get back into their car and GO HOME! We really want to see them at the next water quality meeting. Consider possible risks and include the subject of safety during volunteer training sessions. Also, provide volunteers gloves and other equipment that may reduce risk.

STEP 1. CONDUCTING A WATERSHED SURVEY

One of the first and most important steps in planning and implementing a volunteer water quality monitoring program is to gain an understanding of the watershed that is associated with your particular water body. In essence, watersheds are drainage basins, which can be large or small and spread across city, county or state lines. Your receiving body is very likely the local lake, river or estuary that you're concerned with; however, each potential watershed is unique and is rich with history.

You'll need to gather data about your watershed to understand where your water is coming from and where it is going. The following are some suggestions to consider when conducting your watershed survey:

- Take the time to research the area's natural history, such as its geology and soils. For example, sandy-rocky soils typically drain water through them faster than loamy or clay soils. Do you have more than one type of soil?
- Become familiar with the watershed's geographical area, topography and natural drainage systems. The US Geological Survey (USGS) publishes topographic maps for virtually all of the US. You might want to purchase these (call 1-800-USA-MAPS), outline your watershed and hang it on the wall so you can really see it.
- What changes has the area undergone as a result of human population growth? What is the area's population growth history and expected growth? Remember, more development generally means more runoff and NPS pollution. In addition, look for different land use activities such as forests, farms, schools, neighborhoods and industrial parks.
- Look for trends in the local climate such as wet and dry seasons, average rainfalls or severe weather (such as hurricanes) that could affect your area and your water quality data.
- Familiarize yourself with the area's drainage and flood control systems. You will want to understand how different sites affect the water quality of the watershed through these manmade systems.

Excellent resources for a watershed survey are past research studies from your local college, university or state agency. Also, try your county planning offices, drainage control districts, agricultural extension services, or water management districts for this information. In addition, some of these institutes may be able to provide you with Geographic Information System (GIS) images/maps of your local watershed. A central location for locating all of this information for the State of Florida can be found on the Florida Department of Environmental Protection website at <http://www.dep.state.fl.us> (further watershed-specific information can be located at <http://www.dep.state.fl.us/water/watersheds/about.htm>).

Another good resource of information is the Conservation Technology Information Center (CTIC) Internet web site called *Know Your Watershed* at



<http://www.ctic.purdue.edu/KYW/>. This web site contains common definitions, watershed guides (such as how to build local partnerships and putting together a watershed plan) quizzes, conference announcements and web-based training. But more importantly, you can locate specific information (such as environmental information, state water quality reports, land use, air pollution data, population stats and volunteer organizations) about your watershed. All you have to do is search by your city name, river, county name or five digit zip code. This site will also link you to the EPA Watershed Information Network web site (<http://www.EPA.gov/win/>) with more good information.

After completing your research, create a written document about your watershed that can serve as a resource for planning and can be referenced for public information documents, presentations, and reports. Chances are, the information that you collect will be valuable to other agencies, offices, schools, public officials, and the community.

STEP 2. FUNDING, FUNDING, FUNDING

Now, after researching your watershed, you are even more convinced that your community needs a volunteer water quality monitoring program and you are ready to start recruiting volunteers. But wait...who is going to fund your program? Unfortunately, good intentions still need money for equipment and supplies, which can range from as little as \$850/year to \$60,000/year depending on the scope and size of your program.



Any way you look at it, locating funding is labor intensive and let's face it, not much fun. However, the payoff provides community awareness, community action and, of course, reliable water quality data for the protection of your watershed! There are two important questions that need to be answered when locating potential funding sources, "Why is your water quality monitoring program important?" and "What benefit does the funding agency receive from it?" Once you have the answers to these questions, you are ready to start searching, writing and convincing people that your water quality monitoring program is worth funding. To start you in the right direction, the following discussion includes several different approaches.

STATE AND FEDERAL FUNDING

State and federal agencies (such as U.S. Environmental Protection Agency and the U.S. Geological Survey) whose primary responsibility is protecting the environment may be able to provide some start-up funds for a program. This type of funding is normally through a competitive grant process with set deadlines for applications. The easiest way to locate these opportunities is by contacting them directly or searching their Internet web site. For example, the Florida Department of Environmental Protection Office of Water Resource Management provides \$100-200 million each year to local governments and other recipients to build or improve domestic wastewater and drinking water facilities, to reclaim lands disturbed by mining activities, and to implement stormwater and other nonpoint source management projects (<http://www.dep.state.fl.us/water/default.htm>).

In addition, federal funding opportunities are listed each business day in the *Federal Register*, which can be searched electronically at http://www.gpo.gov/su_docs/aces/aces140.html.

The advantage of federal and state grants is that they can provide a significant amount of funding. However, these grants often have strict application procedures, no guaranteed contract renewals, and limits on eligibility. Writing a proposal for these grants is very time-consuming and the process can be highly competitive.

PRIVATE FOUNDATIONS

Another potential source of funding is private foundations. Local community foundations or private foundations as well as large corporations like Bayer, Microsoft, Exxon, and Toyota have

funding for environmental, community involvement, and educational programs. There are many good directories and databases that will allow you to search foundations such as the *Foundation Center* at <http://fdncenter.org/>. Like federal and state grants, most foundations require a proposal and have eligibility requirements that need to be checked. However, many foundations accept proposals year-round and the proposal guidelines are not as strict or detailed as the federal and state requirements. Foundations can be valuable advocates for your program and may fund the program for a number of years, but their annual funding amounts are usually lower than state or federal grants.

SPONSORSHIPS

The last type of funding source is through local sponsorships, which means going directly to the businesses and industries of your community and requesting funding or donations for your program. Sponsorships normally do not require full written proposals like foundations and grants. However, they do require some detailed information about your program usually in the form of a packet and require some effort in distribution and follow-up phone calls.

Sponsorship packets should include a description of the program (including the goals, volunteer information, water quality monitoring parameters and the duration of the program) and propose different levels of sponsorships with associated benefits such as free advertising and publicity. A business or industry sponsoring your program shows the community that they care about them and their quality of life.

The best way to reward a sponsor is to publicly acknowledge and appreciate their support. Once you obtain your sponsors, there are several ways to recognize and provide them with benefits of sponsorship. Here are just a few.

- ✓ Print sponsor's company logo on volunteer T-shirts, posters, brochures and other educational literature.
- ✓ Invite sponsors to your volunteer meetings and special events.
- ✓ Send sponsors monitoring progress reports and/or newsletters.
- ✓ Mention sponsors during television and newspaper interviews.

STEP 3. DEFINING YOUR WATER QUALITY MONITORING GOALS AND OBJECTIVES

A successful monitoring program begins with the establishment of goals and objectives. Goals are the final outcomes of the monitoring effort and are important to define for the foundation and the direction of the program. Objectives are the specifics of how you will accomplish your goals. The easiest way to develop your goals and objectives is to answer the Why, Who, What, Where, When, and How questions.

WHY ARE YOU DEVELOPING THIS MONITORING PROJECT?

Why is the program needed? Will the program establish baseline data? Is it a stand-alone effort or is it coordinated with another monitoring or management effort? Are the data being collected targeted toward a specific, identified problem or are they to be used in screening for potential water quality problems?

Example: This program will develop a long-term data set which can be used to evaluate changes to the water quality of Lake Gitchigoome. Or, the program will assist the Department of Environmental Compliance in monitoring Nitrate input to Artichoke River from the Hometown Watershed region.

WHO WILL USE THE INFORMATION?

The data that are gathered can be useful to many different agencies and organizations such as federal, state and local governments, soil and water conservation districts, fishery management agencies, water body management organizations, species preservation organizations, and universities. If one of your monitoring program's goals is to provide data of a quality that will be acceptable to a specific agency, it is important to identify that agency's quality assurance requirements.

Example: A goal of our Program is for data to be compatible in quality with data collected by the Marine Volunteer Program of West Florida.

WHO WILL YOUR VOLUNTEERS BE?

Start identifying manpower resources. Excellent volunteer pools are retired persons, scout troops, government employees, and school science clubs. Select volunteers based on their ability to commit to a long term monitoring effort and their eye for detail. Selection of monitors should not be limited to any demographic, but should be based on their willingness to perform accurately and to communicate problems or questions.

Example: Identify, recruit and train one volunteer and one alternate for each site identified as a sampling location.

WHAT WATER QUALITY PARAMETERS WILL YOU MONITOR?

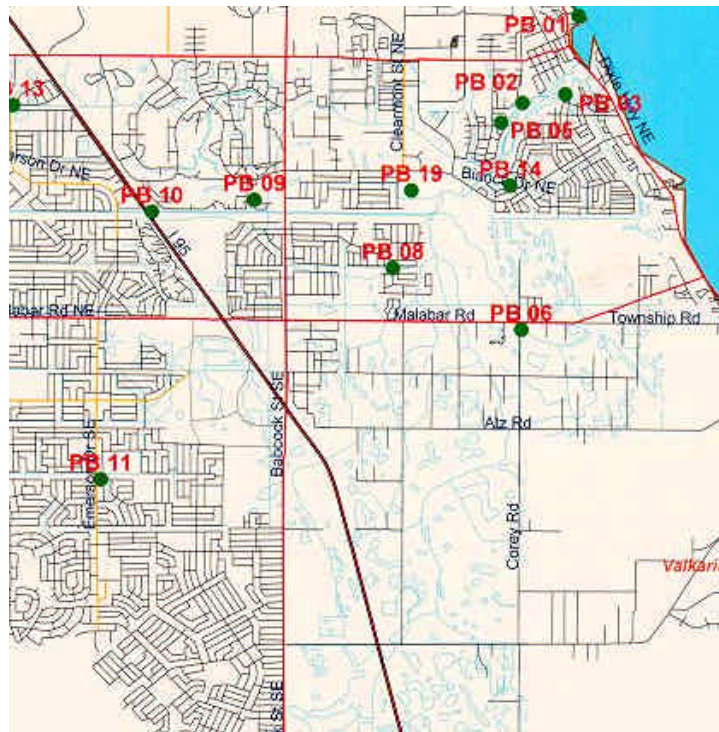
This goal will be related to the information discovered in your watershed survey, the amount of funding available, who will be using the data and for what purpose. Carefully consider which parameters to test for because the testing must be continued consistently for a long time. Remember that a single data point is relatively useless compared to a set of data points taken at the same locations over time. By monitoring the same parameters over time, you may be able to determine water quality trends: “this is where we were, this is where we are, this is where we are going.” Continuously changing parameters or techniques compromises the data and impairs the ability to forecast trends. So, research the parameters and the local watershed needs, decide on what water quality parameters to monitor, and to the greatest extent possible, stick to that decision!

Example: This Program’s goal is to monitor at least the following parameters for 3 years. The parameters include orthophosphate, dissolved oxygen, and secchi depth.

WHERE WILL THE MONITORING TAKE PLACE?

Have you defined your watershed?
You will need to decide where you will locate sampling sites. How close will these sites be to each other and to outfall sources? Did you sample all the important tributaries to your receiving body? Will you establish sites both upstream and downstream from suspect pollution sources? How will sites be tracked?

Example: The example site map indicates sampling locations, which will be continued for the duration of the program.



WHEN WILL THE MONITORING TAKE PLACE?

Specifically, what will the monitoring frequency be? Will volunteers sample seasonally on a weekly basis on a specific day of the week within the same 24-hour period? Will volunteers be asked to sample their location during a certain time of day? Also, consider how often volunteer training and quality assurance checks would be conducted as well as site visits?

Example: This Program will collect samples on the first and third Monday of each month at 11am for the duration of the program.

HOW?

How the monitoring will be done takes into consideration the answers to all of the questions listed above and is identified specifically in the program's Quality Assurance Project Plan (QAPP). The QAPP includes the standard operating procedures that can be used to train volunteers, educate about the project, and most importantly demonstrate sound sampling protocols that assure quality data is being collected. There is more information on QAPPs in aStep 6: Writing your Quality Assurance Project Plan.

More information regarding goals from established, successful water quality monitoring programs in Florida can be found in the Resources section at the end of this guide.



STEP 4: DEFINING YOUR SAMPLING PERIOD AND LOCATION

Discovering trends and changes in water quality requires that monitoring data remain consistent over an extended period of time. Monitoring for just one week or month is unlikely to provide you with credible water quality data and is a waste of effort. This section will briefly discuss common types of sampling routines and provide guidance on locating appropriate sampling locations.

FREQUENCY OF SAMPLING

The frequency of your sampling will largely depend on the goals of the program and your funding. In addition, your sampling period will depend on the seasonal and weather conditions of the program's geographic location. Typical sampling frequencies are weekly, monthly, seasonally, or can occur as 'snap shot' monitoring. The following briefly discusses each frequency.

Weekly sampling generates a large amount of data, which makes your data more reliable and is the best way to predict water quality trends. It is good to monitor weekly if your program is only going to last 6 or 9 months due to funding limitations or weather conditions. However, be careful of monitoring weekly for an extended amount of time, it creates considerable data to input, analyze and interpret and a significant commitment of volunteer time.

Monthly sampling is the most common sampling regime for an extended period of time (years and years worth of data) because it produces manageable data sets and only requires a more reasonable amount of volunteer time. Many volunteer programs that use monthly sampling routines have a large volunteer base (over 100 volunteers) and monitor over a large water body. For example, the Charlotte Harbor Estuaries Volunteer Network monitors on the first Monday of every month within one hour of sunrise.

Seasonal monitoring will generally employ weekly or monthly sampling but is limited to specific seasons because of weather conditions. If your monitoring program objective is to evaluate storm drains, it may be unnecessary to monitor as frequently during drought conditions. Save the money and effort involved for a more productive analysis in keeping with your goals.

Snapshot monitoring employs a network of volunteers that collects samples at the same time on the same day, usually over a broad geographic area, to get a snapshot of the water quality. Snapshots may involve coordination of several volunteer and governmental groups.

TIME OF SAMPLING

Once you have chosen how often sampling will take place, you must now decide what time of day to sample. Samples should be taken on the appointed day at nearly the same time of day regardless of sampling frequency. Sampling consistently and accurately is key to quality data

comparisons. Water quality parameters change rapidly during the day with changes in air and water temperatures and increased sunlight. Aquatic plants, like their terrestrial cousins, conduct photosynthesis during the daylight hours but not at night. Because oxygen is a product of photosynthesis, dissolved oxygen in the water will likely be much higher in the afternoon than it is at first light. Conversely, increasing water temperatures as the day progresses can result in reduced dissolved oxygen levels. Sampling for dissolved oxygen is best conducted early in the morning before influences such as aquatic plant photosynthesis and temperature can impact results. Determine the best time of the day for sampling after considering the parameters being measured, potential interferences with accurate results, and the convenient times when volunteers are most likely to conduct the analysis. Consistent and accurate sampling is more important than the actual time of collection.

SITE SELECTION

From your watershed survey, you should be well equipped with maps of the natural and man-made drainage system for your area. Use those maps to identify monitoring site locations that will help you accomplish the goals of your program. You may wish to monitor specific inlets with concentrated drainage channels caused by bridges, dams, culverts or canals or sites that generally represent an entire water body. Depending on your objectives, you may want to sample sites that are downstream of the various land use activities present in your watershed or monitor upstream and downstream of a suspected pollution source. Above all, remember that volunteers will be conducting the sampling so make sure each site is easily accessible and free of any potential hazards. The most difficult areas to monitor are those where nobody lives, because volunteers want to monitor locations close to home. Try not to concentrate monitoring efforts in the residential areas of the water body and ignore the outlying areas. Search for volunteers to cover the entire water body.

The following are some good general questions to ask while choosing monitoring sites.

- Can the sites be identified on both a map and on the ground? If not, they are likely to be too inconvenient for volunteers.
- Are the sites representative of the watershed and the program goals? Do you have enough sites identified to meet the goals of the program?
- Is enough water available at the site during all of the sampling periods? For instance, during the dry season (if you have one), intermittent streams will have little or no water in them.
- Is the site accessible? When looking at a site's accessibility, you want to see whether the site is on public property with public access or if it is on private property, requiring the property owner's permission. You will also want to consider how close the site is to a volunteer's home. Is it within walking distance? Is the drive five minutes or less? Is the site's location convenient?

- Is there any other monitoring that is taking place at this site? This may be a good or bad thing. If another program is monitoring the same parameters as your program, you may be wasting your effort in replicating their work. However, if another program is collecting different parameters, their data may complement yours and add value to the program. An excellent example of this is the USGS flow monitoring (see photo at left)



conducted on virtually every major river in the US. Flow data can be obtained from USGS and used in conjunction with volunteer monitoring data to estimate pollutant loadings, which is defined as the amount of pollutant per unit time (ex: 22 kg phosphorus / day).

- Are there hazards associated with the site? The safety of your volunteers is top priority. Data are not more important than the safety of your volunteers and for that reason it is essential that each site you select be safe. When evaluating sites, take into consideration such things as the steepness of the embankments, area wildlife and proximity to homes and businesses. Remember that culverts and canals may fill dramatically after a rainfall. Convenient sampling locations such as bridges over streams may be much more hazardous during high traffic or poor visibility conditions.

After you select your sites, it is important to develop a site description visual survey form that describes each site (Appendix A). The site description should contain general information such as the date, water body name, street address, and latitude and longitude. It should also include specific land and water usage. For instance, is the site near single-family homes, apartments, businesses/industry or near crops or pastures? Is the water used for recreational purposes, flood control and drainage? In addition, the entire site appearance is also important to note. Does the water have an odor or peculiar color? Is the stream bank steep? What type of vegetation is nearby? To help describe the site, it is also recommended that the volunteer sketches the site and label approximate locations of key site characteristics.

Describing each site before monitoring begins and periodically throughout the monitoring period is important in presenting your findings. It will help explain the differences between your sites and possibly explain collected data.

STEP 5. SELECTING YOUR WATER QUALITY MONITORING PARAMETERS

Many decisions must be made on the type of data to collect. Consider the groups that will be using the data, what objectives you are trying to achieve, history of the water body, land use impacts, and funding source restrictions. There are four general types of water quality monitoring parameters that volunteers can monitor including visual observations and physical, chemical, and biological parameters. This section will briefly describe the importance of these parameters and how they may be measured.

VISUAL OBSERVATIONS

Visual observations require no equipment. Volunteers can record changes in the physical surroundings of the site by identifying erosion, weather, land use, algae blooms, impacts of construction, recreation usage and the abundance and behaviors of animals. Visual parameters should be recorded each time monitoring is conducted. These data provide good background information about the site and could provide the clues necessary in identifying water quality degradation problems or unusual sampling results. For example, an increase in the suspended sediment carried by a stream may be easily explained by home construction in the area and the associated soil disturbance if this observation is recorded.

PHYSICAL CHARACTERISTICS

Physical characteristics of the water body are can be obtained quickly and easily with the appropriate equipment. The most common types of physical parameters include temperature, color, turbidity, and water flow and height.

Air and Water Temperature

Air temperature and water temperature can have a direct impact on water quality. Temperature affects feeding, reproduction, development and metabolism of aquatic life. As temperature increases, so do biological and chemical activities. As the water temperature changes seasonally, species are able to acclimate to the changing environment with little or no stress. However, rapid fluxes in temperature have adverse affects on aquatic plants and animals. Water temperature changes more than 1 to 2°C within a 24-hour period, may cause aquatic organisms to be more susceptible to diseases, parasites, injuries or even cause mortality.

Most aquatic organisms need a fairly constant water temperature and can only survive under specific tolerance ranges. However, throughout an organism's development these tolerance ranges can change. For example, fish eggs and larvae are more susceptible to sudden temperature changes than the adults due to their sensitive nature during the early developmental stages.

Temperature can also affect other physical and chemical parameters of water. For instance lower water temperatures yield a potential for higher dissolved levels while higher water temperatures tend to result in lower dissolved oxygen levels. Water temperature can also increase the water solubility of chemical compounds and influence the density and salinity of water.

Temperature can be measured in both Celsius and/or Fahrenheit with the use of a simple thermometer. Celsius is the most common reading used in scientific research/papers and is highly recommended for data collection. However, volunteers are generally more comfortable with the Fahrenheit temperature scale because it is more common in the US. Therefore, to make it easy for your volunteers, temperature can be recorded in Fahrenheit and converted into Celsius for water monitoring analysis and reports.

$$^{\circ}\text{C} = ^{\circ}\text{F} \frac{5}{9} + 32$$

Thermometers usually range in price from \$5 to \$35 and can be ordered from scientific and water quality monitoring catalogs (such as HACH Company, Fisher Scientific or Carolina Biological Supply, see resources section for company information) or purchased at a department store. For safety purposes, do not use mercury thermometers. If mercury thermometers break, spill containment and clean-up is very difficult and can contaminate the environment. It is a good idea to attach the thermometers to a lanyard and float so that they can be easily retrieved from the water if dropped.

Note that thermometers, like any other piece of measuring equipment, will need to be calibrated to assure their accuracy. It is not unusual to find good quality thermometers out of calibration by 1-2°C.

Color and Turbidity

The color of water is dependent on factors such as decaying vegetation, dissolved organic materials (tannins), urban runoff, algae, and bacteria. Color of the water can be defined as true or apparent. True color is observed after suspended matter has been removed or filtered out of the sample. Apparent color is how the water appears “as is” prior to the removal of sediment. Color is measured using the platinum/cobalt color scale, which is equivalent to “Hazen” units and uses a simple system of comparisons for measurement. True color does not interfere directly with water quality, however it does affect light penetration. Fluctuations in water color are often found after periods of heavy rain.

Turbidity is a measurement of light scattered by suspended inorganic and organic matter, (such as sediments and algae) and is usually measured in Formazin Turbidity Units (FTU), which are roughly equivalent to Nephelometric Turbidity Units (NTU). Turbidity has a direct impact on water quality. Turbidity can prevent light penetration, lower dissolved oxygen levels, increase temperature, clog fish gills, smother eggs and bottom dwelling organisms, reduce the capture of prey and inhibit photosynthesis. Erosion from urban development and construction sites and excessive algae growth are two primary sources of high turbidity levels.

A physical measurement closely related to turbidity is Total Suspended Solids (TSS); a determination by weight of the amount of suspended material (sediment, algae, etc.) that exists in a known volume of water. This simple measurement is made by filtering a known quantity of water, drying the filter and weighing it to determine the amount of material collected. TSS may then be expressed as milligrams of solids per liter of water.

Table 1. A reference table for different water appearances, turbidity and color levels and possible causes.

Water Appearance	True Color	Turbidity	Possible Causes
Dark, “ice tea” brown but clear	High	Low	Clean water associated with peat bogs or tannins. Not necessarily a pollution indicator.
Tan, brown, clay red, opaque	Unknown	High	Sediment runoff
Bright green, opaque	Unknown	High	Algae bloom, high nutrients
Clear, blue or colorless	Low	Low	Little algae or sediment. Potentially very clean or algae killed by pollution as in acid lakes.

Color and turbidity are observed together and often measured together. One of the most common methods to measure color and turbidity indirectly is with a secchi disk. The secchi disk is a round disk, eight inches in diameter with four black and white quartiles painted on it and is attached to a pre-measured rope. The secchi disk demonstrates water clarity by measuring how deep the observer can see into the water. The reading is taken by lowering the disk into the water until it is no longer visible and is then slowly raised until it is visible. Secchi depth is recorded as the measurement of the visible water column listed on the pre-measured rope.

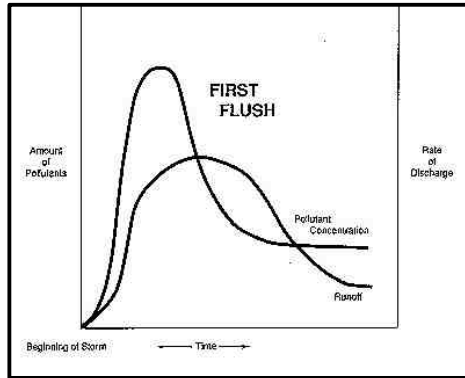
Normally, secchi disks cost approximately \$30 if ordered from a supply company. However, you can reduce the cost by making your own secchi disks. Local high schools are a good resource to assist in the construction of secchi disks. Appendix B provides construction instructions to make your own secchi disks.

Stream Flow

Sometimes referred to as discharge, stream flow is the volume of water that moves over a designated point over a fixed period of time. Stream flow is directly related to the amount of water moving off of the watershed into the stream channel and is often expressed in cubic feet per second (ft³/sec). The measurement of stream flow is important to monitoring efforts because it allows the calculation of “pollutant loading” to the receiving body.

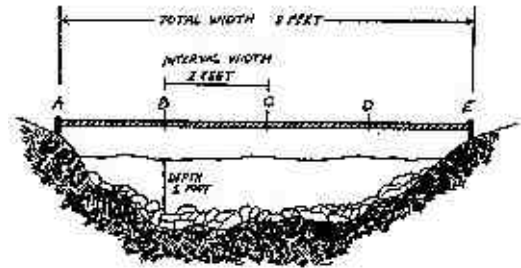
Stream flow is affected by natural and manmade events. During periods of rainfall, stream flow normally increases. Since NPS pollution is related to runoff, it is logical to expect that this increase in stream flow will predict the amount of NPS pollution transported by the stream. This

is true; however, pollution concentration does not remain the same in runoff water during a storm. The first approximately inch of runoff water, the “first flush”, has been documented (Reference 1) to carry as much as 90% of pollutant materials.



Stream flow and its velocity affect water quality and species composition of a stream. Large, fast moving streams are less affected by pollutant discharges than small streams because of the volume and the velocity of the water flowing through them. In addition, the greater velocities tend to keep the sediment and silt suspended for greater periods of time than smaller, quieter streams that allow sediment to settle quickly. Dissolved oxygen levels are also greater in streams due to recreation; the mechanical addition of oxygen due to bubbling and splashing of water over the streambed.

Flow is a function of water volume and velocity that can be calculated mathematically. There are various methods that are employed by volunteer programs to calculate stream flow and velocity (Reference 2). Here is an example of one such method. A 20ft stretch is marked off on the stream and a floating object is used as a visual aid to determine the time. After measuring the cross-sectional area and the depth of the stream you can then begin to measure time. Time is measured with a stopwatch or a watch with a second hand. The amount of time it takes for the floating object (orange or floating ball) to move from upstream to downstream with the other measurements can determine the flow rate.



A note on safety: never enter a boat or moving water without proper equipment such as a life jacket and safety instruction and plan to measure flow rates during times that the stream is not dangerously high. By planning ahead, stream cross sections can be measured safely during low flow and then calculated when the water is high.

$$\text{Flow Rate} = \text{ALC} / \text{T}$$

A= Average cross-sectional area of the stream (stream width X average water depth)

L= Length of the stream measured (this is usually 20ft.)

C= Coefficient or correction factor (predetermined for specific stream bottom)

T= Time, in seconds for the float to travel L (the length).

Exact procedures on calculating stream flow and more information are available in the EPA’s Volunteer Stream Monitoring: A Method’s Manual (2).

CHEMICAL PARAMETERS

Chemical parameters may be the group of analyses most identified when people think of pollution. Examples of chemical parameters are dissolved oxygen (DO), salinity, pH, nutrients such as nitrogen and phosphorus, organic compounds such as oil and inorganic materials including heavy metals. Chemical parameters are measured with a variety of specialized instruments ranging in cost from \$15 to hundreds of thousands of dollars, which of course are beyond the range of funding available to most volunteer monitoring groups.

Dissolved Oxygen

Dissolved Oxygen (DO) is the amount of oxygen dissolved in a given quantity of water. Dissolved oxygen supports animal life in the water just as atmospheric oxygen does here on land. DO is measured and recorded in parts per million (ppm) or milligram per liter (mg/L). Saturation, the maximum possible DO level for a give set of water quality conditions, will vary but is rarely above 10ppm. Optimum levels of DO are between 5 and 6ppm. Levels less than 3ppm are considered to be hypoxic and will not support fish and most other aquatic organisms.

Dissolved oxygen can enter the water through photosynthesis of aquatic plants or through the mixture of atmospheric oxygen and water. Cold water has a higher potential for dissolving oxygen than does warm water and other factors that may influence saturation levels of DO are water salinity, photosynthesis, turbulence and large amounts of organic material.

The DO content of a collected water sample will change rapidly due to the respiration of microorganisms within it. Therefore, measurement of DO needs to be completed immediately at the time of collection. The two most common methods employed by volunteers are the Winkler titration method or a field meter.

- The Winkler titration method measures the amount of one solution needed to react exactly with the contents of another solution (which contains your water sample). The reaction of the two solutions is noticeable by a color change and the amount of the solution needed to produce this color change equals the amount of dissolved oxygen. Sometimes it takes a few practice rounds to perform this method correctly and well-trained volunteers have no trouble performing this test accurately and efficiently. A typical titration kit is fairly inexpensive (approximately \$35), however it does contain hazardous chemicals that need to be handled and disposed of properly.
- Field meters (such as the YSI products featured at right) are a compact and portable instrument that converts electrical signals from a probe. These meters can measure dissolved oxygen and other parameters such as pH, turbidity, salinity and water depth with its multi-sensors and easy to read display. These meters are relatively expensive and need to be calibrated and handled with care



because repairs can be costly. However, they provide quick, accurate and precise data and many companies donate or offer special discounts to volunteer water quality monitoring programs.

Salinity and Hardness

Salinity is the amount of dissolved salts in a given quantity of water. For saltwater conditions such as an ocean or estuary, the dissolved salts are dominated by sodium and chloride, your familiar table salt. Because concentrations are high, they are measured in parts per thousand (ppt). For fresh water, the salt system is usually dominated by calcium and carbonate and is called *hardness*. Because concentrations are low, hardness is measured in parts per million.

Salinity determines the types of species, both plants and animals, which are present in water bodies. The salinity of a water body is dependent upon physical processes such as tides, winds, rainfall, and evaporation. Salinity will decrease with a large amount of rainfall and will increase with extended evaporation.

The distribution of aquatic organisms is dependent upon their tolerances to salinity. For instance, saltwater organisms such as coral reefs, lobsters, and tuna inhabit water with a salinity of about 30-35ppt, while estuarine organisms such as mangroves, sea trout, blue crabs, and oysters inhabit brackish water that ranges from 5-25ppt. Water with very little salinity (0ppt) contains freshwater organisms, such as bass, bluegills, and crayfish. Many marine organisms will utilize different salinity ranges at different times in their life cycle. For example, saltwater fish species often enter estuarine waters for spawning and the hatchlings remain in the estuary until maturity.

An important component of salinity is density. Freshwater has a much lower density than saltwater. When the two mix, like at the mouth of a river, lighter freshwater will float on top of the heavier, denser saltwater. The mixture of these different salinities will be dependent upon wind, tides, water temperature, and volume of freshwater. Sometimes, after a heavy rainfall, this occurrence will dramatically decrease the salinity of the entire water body.

Similar to dissolved oxygen, salinity can be measured through a titration method or by a field meter. However, two other common pieces of equipment are hydrometers and refractometers.

- Hydrometers are easy to use, provide a high level of consistency and are inexpensive. A hydrometer is a calibrated thin glass tube that is closed at both ends with one end enlarged into a bulb containing mercury that causes it to float upright when submerged in water. The scale on the hydrometer can be used to determine the specific gravity or density of the water and salinity readings can be obtained by using a conversion table with these readings and water temperature. However, the worst thing about hydrometers is... you guessed it.... they break and mercury is a hazardous material.
- Refractometers are hand-held equipment that can provide one-step salinity measurements; no tables are needed. Refractometers work by measuring the change in direction of light as it

passes from air into the water, which is called the refractive index. However, as nice as refractometers are, they are expensive costing approximately \$350 each.

pH Value

One of the most common water quality parameters that is tested is pH. A pH test indicates whether the water sampled is alkaline (basic), neutral, or acidic. Results are measured on a logarithmic scale where neutral solutions have a pH of 7.0; acids are below 7.0 and solutions above 7.0 are considered to be alkaline or basic. Optimal living conditions for aquatic organisms are between 6.5 and 8.2. Changes in pH can not only alter water chemistry but also can result in a toxic environment for many aquatic organisms. When the pH drops below 5.0 or exceeds 9.0, species have a more difficult time surviving.

Factors that can affect the pH of a water body are algal blooms, bacterial activity, water turbulence, chemicals and the rate of photosynthesis. Low pH levels can increase the solubility of heavy metals, such as iron and copper, releasing them into the water column and making them more available to plants and animals.

There are several ways to measure the pH value of water. Readings can be taken with a field meter along with dissolved oxygen and salinity or a simple colorimetric kit similar to swimming pool test kit can be used. Because changes in pH can occur rapidly, this parameter should be measured in the field or promptly thereafter.

Nutrients

In water quality terms, “nutrients” means plant nutrients, primarily the various forms of nitrogen and phosphorus. Nitrogen can be found in several forms such as nitrate (NO_3), nitrite (NO_2), ammonia (NH_3), and as organically bound nitrogen (N-C). Phosphorus can also be found in several forms such as phosphate (PO_4), orthophosphates, polyphosphates, and organically bound phosphates.

Nitrogen and phosphorus sources include animal wastes (including humans), decomposing organic material, detergents and fertilizers. In most natural settings, the growth of plants is limited by the amount of nutrients that are available, which is why fertilizers are applied to enrich gardens and yards. When nutrient levels in water become high, aquatic plants respond similarly resulting in algae blooms and excessive growth of unwanted weeds. Algae blooms can cause oxygen depletion and fish kills. Continued inputs of nutrients to a receiving body, with the concurrent growth of plants, may lead to eutrophication.

Eutrophication refers to the natural filling in of water bodies that occurs over hundreds of years as sediments accumulate on the bottom. The unnatural addition of excessive nutrients hastens this process by accelerating plant growth and organic decomposition. The input of nutrients and sediment accumulates on the bottom, reducing water depth and causing excessive muck. Eventually, the water body fills in with plants entirely creating a swamp or wetland. To maintain the water body, costly maintenance is required such as dredging and aquatic weed removal.

Natural levels of nitrogen as nitrate in surface water are typically low, less than 1 milligram per liter (mg/L). However, in wastewater treatment plant effluents it can range up to 30mg/L (EPA 1997). Therefore, nitrate can serve as a good indicator of possible sources of sewage or manure pollution, especially during dry weather.

Phosphate is the limiting nutrient in freshwater and is found naturally in small concentrations, less than 0.2 mg/L. Higher concentrations of phosphate can be found in water near domestic and industrial wastes and agricultural land uses.



Nutrients are typically measured using colorimetric analysis, which determines the chemical concentration in a sample by measuring the intensity of the color it produces through a chemical reaction. For example, specific color reagent is added to a known quantity of sample and it reacts with the nutrient, say nitrate, to cause a color change. The intensity or depth of color is related to the concentration of the nutrient. The two most common colorimetric methods used by volunteer programs are color cubes and field spectrophotometers.

- Color cubes are inexpensive (approximately \$15-20), portable and a fast way to analyze nutrients. With the cubes, volunteers visually compare the produced color to an attached color chart. However, the weakest feature of these cubes is the accuracy (which is about +/- 20%) and most cubes do not detect levels low enough to detect any significant changes in concentration.
- Field spectrophotometers are portable; battery operated light meters that measure the color intensity of a sample and provide a display reading of the light transmittance. A conversion chart easily converts this reading into the concentration in the sample. Field spectrophotometers accuracy (+/- 2%) is much better than the color cubes and chemical concentrations can be detected to the thousandth place (0.001). The cost of spectrophotometers can be prohibitive, starting at about \$1000 plus supplies.

If neither one of the above methods sound right for your goals and budget, you may consider having an independent laboratory analyze your samples. Volunteers would be responsible for collecting and preserving samples (which usually means to placing them on ice). The cost generally varies according to what and how many parameters are being tested. However, if the group provides numerous samples to analyze at one time, the cost per test is often reduced due to economy of scale.

Organic Chemicals: Pesticides and Petroleum Hydrocarbons

Organic chemicals include pesticides such as insecticides and herbicides, petroleum hydrocarbons such as oil and gas, and generally any other manufactured chemical such as those used in paints, furniture strippers, and pool cleaners. The ones most likely to be found in surface water bodies are pesticides and hydrocarbons. Pesticides exist in a tremendous variety of formulations depending on their application. The problem with pesticides is most are “broad spectrum” and will kill a large number of different organisms, both those that hurt and help the garden and the natural system. Furthermore, some pesticides are persistent and will bio-accumulate in other species up the food chain causing species extinction. The use of one pesticide (DDT) nearly eliminated the Bald Eagle from the continental U.S., before the use of the chemical was banned. The sources of pesticides are as numerous as their potential uses and generally end up in stormwater runoff as a result of over-application.

Petroleum hydrocarbons typically enter the aquatic environment from storm drain run-off. Common sources of petroleum hydrocarbons include automobiles, gas stations, auto repair businesses, and mishandling of used oil by homeowners. Additionally, petroleum products may enter a surface water body through underground sources such as leaking underground storage tanks. Other organic chemicals that may end up in water bodies due to mishandling include chlorine, toluene, degreasers, fiberglass resins, and paint thinners.

This important parameter set can be collected by a volunteer organization with proper training but requires the analytical attention of a professional laboratory. Laboratories can be found under *Environmental Laboratories* or *Environmental Consultants* in your local Yellow Pages.

Metals

Heavy metal contamination from NPS pollution is less common from point sources. Perhaps the best example of this is mercury. Combustion of coal and incineration of waste have led to elevated levels of mercury in the atmosphere. The mercury is washed out by rain and deposited in sediments. Under certain conditions, bacteria can metabolize mercury to form “methyl mercury”, an extremely toxic organo-metallic compound. This is a well-documented problem in the Everglades (Reference 3). Other sources of heavy metals include used motor oil and leaded gasoline.

Common point sources for metal contamination are mines, abandoned or active, and mine tailings incinerator sites, foundry or metal working industries and metal plating industries. If your watershed survey has identified these types of industries, you may want to consider adding some selected metals monitoring to your program. Examples of commonly monitored metals include arsenic, chromium, copper, lead, mercury, nickel, silver, selenium and zinc. Select the metals to be monitored based on the industries identified in your watershed survey. As with organic compounds, this parameter set can be collected by volunteers but requires the analytical attention of a professional laboratory.

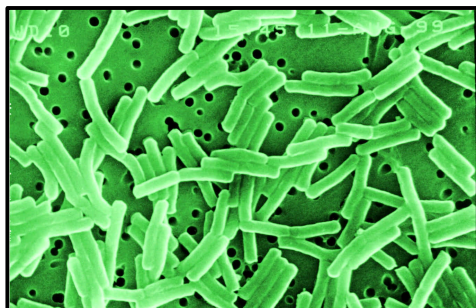
Safety Note: Many chemical and metals are hazardous! During routine surface water quality monitoring, it is highly unlikely that anyone will come into contact with a chemical spill or concentration that could cause them harm. However, if a volunteer should find evidence of a spill or dumping, they should retreat immediately from the site and call the local emergency response network or fire department. A chemical spill must never be approached by an untrained individual.

BIOLOGICAL MONITORING

Monitoring biological parameters is one of the most cost-effective methods of assessing water quality. Little specialized equipment is required, virtually no waste is generated and it's fun. Common biological communities or parameters monitored are bacteria, plankton, benthic (bottom dwelling) macroinvertebrates, submerged aquatic vegetation, amphibians, and fish. By monitoring these biological communities, scientists are able to assess the function of the aquatic system more quickly than from physical and chemical parameters. Biological communities are sensitive to chemical and physical changes that take place in a water body and these changes can reflect the overall health of the watershed. Below, three of the most common biological parameters monitored by volunteer programs will be discussed. Resources to consult for further information on this topic are recommended in the resources section of the manual.

Bacteria, Disease and Fecal Coliformes

Many diseases can be transmitted from human to human by water. Historically, human waste often contaminated drinking water supplies. Waste produced by a diseased individual presents a greater potential for infection to others. The realization of this in the early 1900's led to the construction of public water systems and chlorination of drinking water that has vastly improved public health.



Disease causing organisms cover a wide variety of life forms including viruses, bacteria, protozoans, algae and worms. Some examples are *Hepatitis* (virus), *Salmonella* (bacteria), *Naegleria* (protozoan causing meningoencephalitis), *Anabaena* (blue green algae which produces cancer causing chemicals) and *Schistosoma* (worm causing schistosomiasis). Because these organisms have vastly different life cycles, the culture and identification of each is quite different. Further, culturing

pathogens or “disease makers” is personally hazardous. No one wants to experience these diseases first hand! In order to reduce the difficulty and personal hazards associated with handling pathogens, coliform bacteria are used as an indicator organism.

Coliform bacteria, like *Escherichia coli* or *E.coli*, occur normally in the intestines of all warm blooded mammals including humans. Huge numbers of these organisms are excreted in human feces. Hence, the number of coliform bacteria present in water can be directly related to the amount of feces in the water. When feces are present as indicated by coliform bacteria, other

pathogens may be present as well. Although coliform bacteria die relatively rapidly once they have been excreted, they are hardier and longer-lived than most other pathogens and can therefore act as a good screen for the presence of pathogens. If coliforms are present, other pathogens probably are too, if they are absent, the water is considered bacteriologically safe for human consumption or recreational purposes. Because the analysis of coliform bacteria requires culture of a potentially hazardous organism, laws typically require that it be conducted under the controlled conditions of a regularly inspected laboratory.

There are many types of coliform bacteria and water quality measurements usually distinguish between “total coliform” and “fecal coliform” types. Typical coliform tests are the Most Probable Number (MPN) test, the Membrane Filter (MF) test and a Presence-Absence (P-A) test. All testing for coliform bacteria involves collecting a water sample, inoculating a media favorable to and selective for coliform growth with the sample water and then allowing the bacteria to grow for a period of time. The bacterial colonies are then quantified by a variety of methods and a total coliform count is calculated. The result of this test is usually expressed as number of total coliform per 100 milliliters sample water. If the total coliform test demonstrates a positive result a second step can be taken to further identify the origin of the bacteria. Typically, the cultured positive media containing the coliform bacteria is used to inoculate an even more selective media in which only *E. coli* can grow. If this test indicates a positive result, the colonies are quantified and a fecal coliform count is calculated. The fecal coliform count is similarly expressed as fecal coliform per 100 milliliters sample water.

When examining water quality criteria for your location you will likely find standards for both total and fecal coliform concentrations. In Florida, the maximum concentration of total coliform allowable in untreated fresh water used for general recreation purposes is 2400 per 100 ml. Maximum fecal coliform concentration for the same water is only 800 per 100 ml. Average concentrations of either should be less over the course of a month. The EPA recommends that water used for swimming should not exceed 126 *E. coli* per 100ml on average for 5 samples taken within a one month period. Treated drinking water has a much more stringent requirement; zero coliform per 100 ml is the allowable maximum.

Safety Note:

It's very unlikely that routine surface water monitoring would cause anyone to become infected with a waterborne disease. However, water quality issues are often caused by untreated or poorly treated sewage discharges or discharges of animal wastes from agricultural facilities such as feedlots, hog farms or chicken houses. When monitoring water that may be contaminated with coliform bacteria, use appropriate safety equipment such as gloves and a mask. Volunteers should be properly trained in safety and hygiene protocols prior to monitoring these settings.

Chlorophyll as a Measure of Phytoplankton Primary Production

Phytoplankton are unicellular, microscopic plants. They live in virtually all water and are the base of the food chain just as terrestrial plants are on land. Phytoplankton engage in photosynthesis, the creation of simple sugars from carbon dioxide, water and sunlight. The amount of photosynthesis occurring is termed primary production by scientists. On land, primary

production is easily measured by the estimating the amount of plant material growing in a specified area (i.e. bushels/acre). In the water, primary production is measured by filtering phytoplankton from the water, extracting their chlorophyll and measuring it. Scientists then calculate the primary productivity of water from the chlorophyll content. Just as in a farmer's field, addition of fertilizer (plant nutrients) increase crop yield (primary production). High primary production is usually a symptom of eutrophication.

Measurement of chlorophyll typically follows this sequence. Water is collected and filtered through a small pore (0.45 micrometer pore size) glass fiber filter. The filter with the phytoplankton is then ground in the solvent acetone using a specialized grinding tube. The acetone is an organic solvent that dissolves the chlorophyll from the ground up phytoplankton cells. The acetone, now bright green with chlorophyll, is then filtered to remove dead cells and filter fibers and analyzed using a spectrophotometer. The amount of green light absorbed, as measured by the spectrophotometer, is related to the amount of phytoplankton in the water, which is related to the amount of primary production.

Macroinvertebrates

Macroinvertebrates are animals that are visible and do not have a backbone such as insects, crayfish, clams, snails and worms. They are good water quality indicators because they are easily affected by changes in water conditions and can show environmental impacts from habitat loss or degradation. They are also easy to collect and a critical component of the food web.

However, monitoring macroinvertebrates alone cannot tell you why certain species are present or absent. These studies need to be accompanied by habitat and water quality monitoring data. Volunteers need to be taught macroinvertebrate identification usually to the taxonomic level of order and professional guidance from a scientist is recommended for quality assurance.

The following items are needed to collect macroinvertebrates:

- ✓ Fine mesh kick and dip nets
- ✓ Large, shallow white pan
- ✓ A good taxonomic key
- ✓ Magnifying glass
- ✓ Buckets
- ✓ Tweezers
- ✓ Data collection form (Example located in Appendix C)



Several different measurements of macroinvertebrate community health are routinely employed to determine the status of a system. These are:

- Taxa richness: the number of different types of organisms present in a system.
- Shannon-Weaver diversity: an index specified in the Florida Administrative Code as a measure of biological integrity.

- Percent contribution of the dominant taxon: related to diversity, used for analysis of qualitative samples.
- Numbers of pollution sensitive taxa: several different invertebrate indices based on this principle, including the Florida Index and the Lake Condition Index.
- Ephemeroptera/Plecoptera/Trichoptera Index: an index which sums the number of these kinds of organisms present. A related parameter, the Ephemeroptera/Plecoptera/Odonata Index, is also sometimes used.
- Community structure: measurements of shifts in proportions of major groups of organisms, compared to reference conditions.
- Trophic composition/feeding guilds: determination of shifts in the feeding strategies of invertebrates.
- The Stream Condition Index for Florida (SCI): a composite macroinvertebrate index made up of several of the measurements listed above.
- Habitat Assessment: quality of the local environment with respect to the needs of the organisms investigated.

The Standard Operating Procedures used in performing benthic macroinvertebrate analyses can be viewed or downloaded from FDEP Biology Section Standard Operating Procedures (SOPs) at www.dep.state.fl.us/labs/cgi-bin/sop/biosop.asp.

Other Biological Monitoring

The abundance and diversity of aquatic species such as submerged aquatic vegetation (SAV), jellyfish, fish, and frogs can also be monitored. Monitoring of sea grasses or SAV is usually conducted by defining transects and quantifying a percentage of each sea grass species occupying the transect based on visual estimates. Jellyfish and fish species can be counted on routine visits to a fixed location. Monitoring of jellyfish and fish can include identification of specific species, numbers of different species, or total numbers seen. Types and numbers of frogs can be estimated by identifying the call and volume of frog song.

STEP 6. WRITING YOUR QUALITY ASSURANCE PROJECT PLAN

Now that you have researched your watershed, assessed your monitoring objectives, and decided upon monitoring parameters, it is time to define the standard operating procedures and quality assurance practices for the program. The Quality Assurance Project Plan (QAPP) includes Quality Assurance and Quality Control (QA/QC) procedures that outline a set of operating practices known to produce data of acceptable quality for the intended use.

- Quality assurance is the result of a written plan that defines and confirms methods and actions known to produce data of defensible quality. Quality assurance proves that data are accurately reported. The Quality Assurance Plan describes in writing all aspects of volunteer training, sample handling, instrument calibration and maintenance, testing methods, validation and data reporting. It is also a written history that confirms the completion of these activities.
- Quality control is a component of QA that refers to activities conducted to ensure consistent and accurate analytical results. Quality control measures and estimates potential errors in the system and defines actions to minimize the possibility of sample interferences, inaccurate testing procedures, or data reporting errors. For example, regular instrument checks will lower the possibility of undetected instrument malfunctions affecting the quality of the data.

The extent of the QA/QC procedures that need to be employed by a monitoring program will designate whether the data is low, moderate or high quality and will depend on your program's objectives. If your program is collecting data to sue a industry, and the data will be used for legal purposes, then the highest QA/QC procedures must be employed. A program that is identifying trends in water quality over decades may only need to employ moderate levels of QA/QC. The higher the level of QA needed, the more laboratory testing required to duplicate and confirm results and the more costly the program becomes.

Also, consider the ultimate users of the data and potential funding sources when deciding what level of QA/QC to employ. Regulatory agencies such as the U.S. EPA or the Florida Department of Environmental Protection have specific QAPP requirements. They may assign a Quality Assurance Officer to assist in QAPP preparation, provide a format or existing template, review the QAPP to assure all required procedures are present, and approve the QAPP. Don't underestimate this requirement. It is very unlikely that your data will be useful to a regulatory agency without their approval of your QAPP and you may need to depend on them for funding. For more information visit the Florida Department of Environmental Protection QA web page at: <http://www.dep.state.fl.us/labs/qa/index.htm>

The U.S. EPA has published a very helpful manual for developing your QAPP, *The Volunteer Monitor's Guide to Quality Assurance Project Plans* (Reference 4). The following provides a basic overview of the elements described in this document:

1. **Project Management:** This section of the QAPP should identify all key personnel that are involved in the program and their specific roles; identify the problem or situation you are planning to monitor; describe the work your volunteers will perform and where it will occur; describe how good your data need to be to meet your goals; and identify your volunteer training requirements.
2. **Measurement / Data Acquisition:** This section describes sampling and analytical requirements; quality control requirements; instrument testing and calibration requirements, and data management requirements.
3. **Assessment and Oversight:** This section is the recorded history of the activities that describes the volunteer training methods and frequency and how you will your record that information. How quality assurance methods will be reviewed, accounted for, and corrected is also discussed in this section.
4. **Data Validation and Usability:** Section 3 is about reviewing your QAPP during the course of the project to assure that the Plan is working. This Section is about reviewing your data to assure that it's correct. The elements in this Section describe how you will decide that data are correct or incorrect and what to do when they are not.

Remember... your QAPP is a work in progress and may need to be revised and/or polished on occasion. Once your QAPP is completed, you are ready to start recruiting and training volunteers.

STEP 7. VOLUNTEERS: RECRUITING, TRAINING, AND KEEPING THEM INTERESTED

“Never doubt that a small group of thoughtful committed citizens can change the world; indeed, it’s the only thing that ever has.”--Margaret Mead, Anthropologist

In addition to quality data, water quality monitoring volunteers offer benefits that paid monitors cannot provide such as a larger monitoring network, community support, environmental stewardship, and an expanded education force. In addition, citizen volunteers can provide local insight into the area’s history and changes that have occurred over the years. However, the key to any good volunteer program is effective recruiting, training, and retention.

VOLUNTEER RECRUITING



The first step in volunteer recruitment is defining the role of your volunteers. This is an important step, because from the start, volunteers need to know what is expected from them and the commitment level involved. You may want volunteers to commit to monitoring the water quality at a specific site on the first Monday of the month for an entire year. You may also want them to attend two-hour meetings every two months and a refresher-training workshop every year.

In addition, you may need to note other commitments besides time that would be required from volunteers. For instance, water quality monitoring sites may be located in the lake (not on the shoreline) and volunteers would need a boat to travel to their site. In this case, volunteers need to know that they are expected to not only volunteer their time but also the use of their boat and gas.

There may be different volunteer jobs that need to be filled. Beside monitors, the program may benefit from volunteers employed to do data entry, administrative or public relations work, volunteer supervisors, or website design. A job description should be written for each job, the skills and experience needed to be effective, and the volunteer commitment.

After writing detailed job descriptions for each volunteer position, make a book or file of the job descriptions to share with potential volunteers during recruitment efforts and ask volunteers to

agree to their job by signing a letter of agreement or commitment to that job. This assures that the volunteers will fully understand what is expected from them and that you consistently describe the job accurately.

The next step is deciding whom to recruit. Established volunteer monitoring programs indicate that no particular demographic of volunteer is better at performing the job of water quality monitoring. The type of volunteer needed (ex. students, adults, retired, working professional, etc...) is more dependent upon the specific job. A program that requires monitoring to be conducted weekly for an entire year may be too time-consuming for students. Some monitoring sites that might have steep embankments or other physical barriers could make monitoring hazardous for a person with physical disabilities. Consider the commitment of time and resources as well as the skills and physical abilities needed for each volunteer job and make a list of volunteer types.

Once you have decided the type of volunteers you want to recruit, it is time to begin recruiting. Brainstorm places in your community that you may come in contact with people who will commit to your program. Consider the following already brainstormed list and add your own local ideas.

Where to post volunteer ads:

- city, community, neighborhood and school newspapers
- paid ads
- human interest stories on your program in print or broadcast media
- professional association, senior center, church and club bulletins
- employee newsletters
- radio and TV PSAs, fundraisers, and "volunteer-a-thons"
- celebrity spokespersons
- posters on community bulletin boards, at library, grocery stores, laundromats, community centers, college campuses
- posting services and TV message boards
- on-line chat rooms, volunteer recruiting services, nonprofit sites, your website
- "Bring a Friend" teas for current volunteers
- open house/agency tours
- short, upbeat talks at community or professional organization meetings
- buttons/bumper stickers
- volunteer fairs and other community events
- go in with other agencies for publicity during Volunteer Recognition Week
- recruitment services through United Way, RSVP, et cetera
- community education classes related to your particular client base or services
- enclosure or "mention" in agency fund raising literature
- special announcements at agency fund raising events
- school community service programs
- court-ordered community service programs
- AmeriCorps program
- your current clients, staff, board and volunteers
- volunteer hotlines

Your program can be announced to these specific groups and/or the general public through press releases, public service announcements, newspaper articles and presentations. In addition, brochures and flyers describing the program goals, objectives and requirements should be developed and distributed at public places such as libraries, local government centers and at local workshops and festivals. These brochures and flyers are also helpful in providing information to interested volunteers that are responding from a PSA or press releases.

When potential volunteers respond to your program announcements, an application should be sent to them. Volunteer applications should contain personal information such as name, address, phone number and inquire about days they are available to monitor and attend meetings. In addition to provide further insight about the volunteer, the application should also address these questions.



- Why is the volunteer interested in water quality monitoring program? Is it just for their child's science fair project (which is okay for a short monitoring program but may not be good candidate for a long-term program)? Or do the volunteers want to make a difference in their community and environment?
- What is their occupation? By knowing your volunteer's occupation it can help you with teaching the monitoring procedures and provide insight about their availability. For instance, a retired military colonel may not have a lot of experience in water chemistry but may have an excellent eye for detail and some free time (since he is retired).
- What are their special interests and hobbies? The answer to this question can provide you with ideas for guest speakers and lets you get to know your volunteers better.
- How far they are willing to travel to monitor a site. Do they have a site in mind?

The application will assist you in selecting the right volunteer for your program and provide the volunteer extra time to consider their commitment level to the program. Include detailed information in the application package about the job so that the volunteer understands the commitment needed. It is better to have fewer good volunteers than more volunteers that aren't dedicated to performing the work correctly. Give the potential volunteers a week to read the information, complete the application, and think about what is expected of them prior to making a commitment. Check the submitted volunteer application and interview the volunteer before giving them the job. Make sure from the information provided, that the volunteer pays attention to detail and answers questions accurately, that they are able to commit the resources needed, and that they are willing to learn and follow monitoring methodologies.

Committed volunteers are essential! Without them you will waste your time training and not obtain consistent results.

The H₂O Guard Volunteer Application

Please Print:

Name: _____

Address: _____

City: _____ State: _____ Zip: _____

Telephone #: (____) _____ Alternate #: (____) _____

Are you able to monitor for an entire year? ___Yes___No

If no, what months are you available? _____

Do you have a Backup Buddy, to take your place? ___Yes___No

Name of Backup Buddy: _____

Telephone # of Backup Buddy: (____) _____

Will you be able to attend meetings every other month? ___Yes___No

Do you have a monitoring site in mind? ___Yes___No

Location of site: _____

Occupation: _____

___Full-time

___Part-time

___Retired

How long have you lived in Florida? _____Years

Special Interests or Hobbies: _____

Why are you interested in becoming a member of the H₂O Guard? _____

VOLUNTEER TRAINING

It is important to provide volunteers with everything they will need to succeed, such as knowledge, resources, and support at training workshops throughout the program. Initiate training with one or two kick-off training workshops prior to sampling that are informative, hands-on, and interactive. They should introduce the program's goal and objectives, provide background information, and review what is expected from the volunteers. In addition, volunteers should be able to practice their monitoring techniques and be encouraged to ask plenty of questions.

The overall goal of the kick-off workshops is to have volunteers gain the ability to successfully use the equipment and be able to practice safety procedures, proper chemical disposal, and demonstrate proper testing techniques. In addition, volunteers should have a full understanding of why the program was initiated, where the program is going and how they fit into the big picture. But beware, too much information in such a short amount of time can be overwhelming and an overwhelmed volunteer could mean a short-term volunteer.

After the initial training session, continue training sessions to update volunteers on the latest protocols or QC procedures and test their accuracy with blind samples. If necessary, you may be able to mail a blind sample to your volunteers of a known solution and have them measure and report the results back to you.

Training sessions can also be an avenue to investigate errors in sampling techniques and data reporting. Encourage interaction and open discussion during which volunteers can show how they conduct their routine sampling events. You may be able to see nuances in their sampling procedures that are making some results consistently more accurate than others.

VOLUNTEER RETENTION

People volunteer for different reasons, such as their dedication to their environment, fulfillment of community service hours, scholarship eligibility, exploration of new opportunities, cultivating new interests, religious obligation, community recognition, and personal growth. However, keeping them interested in and involved with the program requires good communication, sometimes-extra responsibilities, and appreciation.

One way to assess your program's ability to retain volunteers is to conduct an exit interview. Volunteers leaving an organization may provide more feedback on issues that previously went unsaid and they can provide an overall picture of the volunteer management program from an interesting perspective. Develop an exit interview that asks why the volunteer is leaving as well as about the volunteer's experience overall, whether they received adequate training and supervision, what they liked best/worst about the experience, and if they would consider returning in the future.

Communication

Communicating with volunteers is the first step to keeping them happy in their job. A volunteer coordinator must stay in contact with the volunteers to assess their situation, respond to their needs, evaluate their performance and listen to their input. The volunteer coordinator may encourage communication by following the following suggestions (adapted from Connors, 1995):

- Make sure that the volunteer knows what the task is and why it is important to the overall scheme of things.
- Provide positive and corrective feedback.
- Involve volunteers in the planning and decision making regarding the task they do.
- Create a team relationship amongst paid staff, clients, and volunteers.
- Provide volunteers with authority, not ultimate responsibility.
- Listen and value volunteers' input.
- Be accessible, not intimidating or overshadowing. Provide volunteers with a contact name and number.
- Anticipate problems and plan for solutions.
- Acknowledge and appreciate what gets done.
- Never waste volunteers' time.

Volunteers need someone with whom they can easily communicate and feel comfortable. The volunteer coordinator should be outgoing and responsive to their needs. Do not underestimate the need for a volunteer coordinator because without a dedicated, friendly, and organized volunteer coordinator, the program will not last very long. It is up to the volunteer coordinator to keep the volunteers trained, interested, and involved.

Another key component of good communication is to provide informal, informational meetings for your volunteers. These meetings are essential for morale and keeping the lines of communication open between the volunteers and coordinator(s). Meetings can provide volunteers with a forum to share data and to increase their knowledge of water quality issues and other important environmental concerns through presentations and guest speakers. In addition, meetings provide the perfect opportunity for necessary quality checks and can also serve as another avenue for recruiting new volunteers. Placing a press release in the newspaper about a guest speaker at the upcoming meeting may generate interest from other potential volunteers.

Promotions and Extra Responsibilities

Volunteers may become bored with a task and decide to move on, unless given something else to do. Others may appreciate being singled out for a "promotion" to a supervisory role in the volunteer corp. It is better to keep a volunteer in another capacity (if needed) than to lose them altogether. Consider other volunteer or paid staff duties such as newsletter editor and publisher, central supply person, quality assurance officer, training officers, data entry technician, or public relations person. The volunteers will bring a more rounded understanding of the program to the new job and appreciate the change.

Appreciation

Volunteers need to be appreciated and publicly recognized for their hard work and dedication. Different types of volunteers prefer to be recognized in different way. Some prefer a hand written personal note, others like to be applauded in front of their peers, and others like political recognition. Volunteer appreciation can be accomplished in a number of different ways.

- Provide regular and sincere praise, say “Thank You”, make people glad they are participating.
- Provide food and refreshments at meetings. For the holidays, have special events, make “trick or treat” bags for Halloween, or make cookies for Christmas.
- An end-of-the year celebration picnic or luncheon is a nice way to recognize volunteers and provide them with an opportunity to share their water quality monitoring results and experiences with their families and friends. Invite guests such as city officials, scientists and the media so that they too can learn about the success of your program.



- A Certificate of Appreciation is an easy but meaningful gesture of gratitude.
- T-shirts and hats are great for morale and make the volunteer feel part of group. Some volunteer programs provide the T-shirts and hats after the kick-off training workshop while others provide the items as a reward to volunteers that have monitored over a year.
- Publish them! News articles that discuss water quality results, interviews with volunteers about their data collection efforts, list them on your website, and cite them in technical reports. Be sure to send them a copy.

STEP 8. DATA SHEETS AND WATER QUALITY MONITORING

Now, you have conducted your watershed survey, located funding, selected your water quality monitoring parameters, equipment and sites and recruited your volunteers. Before monitoring begins, you must determine how the data will be reported, analyzed and distributed. This short chapter will talk about the data sheets.

DATA SHEETS

All water quality-monitoring data need to be recorded at the time of collection on data sheets. Due to the fact volunteers are collecting data out in the elements, data sheets should be printed on waterproof paper and written in pencil or permanent ink such as a Sharpie® marker (ink pens will run if wet). If a mistake is made on a data sheet, the volunteer should draw a line through it and initial. Volunteers should never rewrite the data on a clean sheet of paper; this could produce additional transcription errors. There is a potential for error every time the data is transposed, so limit the number of times that data needs to be entered or written.

Data sheets should be easy to understand and include information such as the specific site location, the day of the week, date and time of sampling and the name of the person sampling. The data sheet should also contain areas to note current and recent weather conditions, amount of precipitation, air temperature and any physical site observations (such as oil slicks, dead or living animals, algae blooms and odors). If your program monitors parameters that require conversions (for example, converting Fahrenheit to Celsius or phosphorus to phosphate), be sure to provide your volunteers with plenty of space along with the formulas to make the conversions. If the sample requires laboratory delivery, the date and time of the sample delivery should be included along with the employee who checks in the sample. In addition, leave plenty of room at the bottom of the data sheet for the volunteer to write any comments. Often these comments have proven to be very helpful when interpreting the data.

When creating your datasheet it is a good idea to review other data sheets from other programs for formatting ideas (Appendix C). Also, if your program will be using the services of an analytical laboratory, you may want to have a correlation between the laboratory forms and the data sheets. Correlating your data sheets with your database and spreadsheets will ease data entry.

STEP 9. ALL OF THIS DATA, NOW WHAT?

At this step, if volunteers are collecting data and sending it to you, data sheets may be starting to accumulate. This section is going to discuss how to store, manage, retrieve and analyze the data.

DATA MANAGEMENT SYSTEMS

Before receiving data you must decide on how you are going to store, manage and retrieve it. Sure you can keep it in a three-ring binder, but with the affordability of computers and software, computerized data management system can offer many more advantages. Computers can store large amounts of data within a small amount of space and facilitate data sharing and presentation. In addition, computers allow data to be sorted and viewed in different ways (e.g., by site, by sampling date); calculations and statistics can easily be performed with preset formulas; and data can be easily transformed into graphs, charts and tables. If entering data into the computer, it is still advisable to keep original data sheets in a three-ring binder to confirm data entry at a later date. There are two types of applicable computerized data management systems: spreadsheets and databases.

Spreadsheet programs (e.g., Lotus 123, Excel, and Quattro Pro) are one of the most widely used data storage and retrieval systems of volunteer water monitoring programs. Spreadsheets are easy to use and require little time for set up while providing many functions such as calculations, statistics, and graphical analysis. In addition, the users are able to sort and list through data and create custom graphs and charts. Spreadsheets are not as efficient as databases at storing, manipulating, and managing the vast amounts of data generated by monitoring programs.

Databases (e.g., dBASE, Paradox, Access) allow for convenient centralized storage of information that can easily be expanded and shared between other databases. Users can create and edit tables of data and perform queries, analysis, and searches of stored data. The database manager is also able to set guidelines, entry form templates, and field parameters and ranges that reduce human error. Setting up databases is often time-consuming, however once completed, maintenance of the database is very low. In addition, there are programs on the market today that are capable of making your database accessible on the Internet.

Placing your data on the Internet allows volunteers to enter data electronically and share the database worldwide with other volunteer monitoring programs and scientists. The only caution with these Internet sites is that good quality control measures need to be in place for any data that are entered into the system.

One of the most utilized online databases for water quality monitoring is STORET. STORET is a free national water and biological data **STOR**age and **RETR**ieval database maintained by the U.S. EPA. STORET works well with other spreadsheet programs (like Microsoft Excel, Lotus 1-2-3, Coral and Quattro Pro) allowing data to be moved between systems. For data to be used effectively by the Florida Department of Environmental protection it is important that it be entered into the STORET database.

As you can see, both of these systems have some advantages and disadvantages. To help you decide which system is right for your program, you will need to analyze your data requirements. The following questions will get you started on the right track:

- Will one or several people be responsible for entering the data?
- Do you want to post the data on the Internet?
- Will you want to produce numerous charts and graphs?
- Do you expect the volume of data to increase over time?
- How much does the software cost and what can the organization afford?

DATA ENTRY

Entering data is a tedious process, but a very important one. By keeping current with data entry, you can easily track trends and provide up-to-date progress reports on the program. For example, a fish kill may occur and the community will contact your program to request the latest water quality data. If the data reveals a sudden drop in dissolved oxygen, you may be able to speculate about the cause of the fish kill. Prompt data entry and analysis assures that you will be prepared to respond to scientific inquiries and identify dangerous trends, potentially preventing future episodic events. There is really no sense collecting data, if it just going to be stored in binders and never analyzed. Steven Hubbell from Texas Watch would say, “You might save the day, impress the governor or win an award” with the data that need to be entered. So, go to it, and start entering the data.

As soon as the data sheets are returned they should be immediately reviewed for completeness and accuracy. If you wait several months and find discrepancies it is more difficult to resolve them. When reviewing data sheets, consider the following:

- Did the volunteer complete the entire datasheet? If not, check to see why.
- Did the volunteer complete all of the calculations or conversions correctly?
- Are the decimals in the right places?
- Were proper units of measurement used and recorded?
- Do the readings make sense? If a value seems extreme, look for an explanation on the datasheet or call the volunteer. You want to make sure it wasn't an equipment problem or human error.

After the data sheet is reviewed and initialed by the reviewer, it is ready to be entered into your data management system. To ease the data entry, arrange your spreadsheet or database to look like your datasheet (i.e., in the same order). Some databases allow the creation of a data entry form that is identical to the data sheet. The data entry person should also initial and date the data sheet after it has been entered. The series of checks and initials show who reviewed it and when the data sheet was entered so if there are any questions, you will know whom to contact. As often as possible, print out the data entry screen and have someone proof the entered data with the original to ensure that there are no transcription errors.

Data entry can be a pretty boring task. Sometimes it's more fun to have two volunteers do the entry with one reading the data and the other typing it in. After the data have been input, the two can switch places and check the entries.

ANALYZING YOUR DATA

If you have a large data set that has been collected over several years, your water quality story will get lost in the numbers. By using statistics you can reduce the volume of the data set and summarize, interpret, and draw conclusions about your data. This section will focus on descriptive statistics, which summarizes data in terms of central tendency and distribution and is a great starting point for analyzing your data. Inferential statistics, which test significance and methods of trend directions, will not be discussed as they are beyond the scope of this manual.

If you are interested in testing hypotheses, plotting trends, or determining correlations from your data, you'll be well advised to speak to a statistician during the planning stage of your monitoring effort. Statisticians hate to be brought a pile of data and asked, "What can you do with this?" Try recruiting statistical advice or volunteer statisticians from your local university.

Common statistics include arithmetic means (or averages), geometric means, medians, ranges and standard deviations. These statistics are fairly easy to compute, but be aware that these summaries become highly unrepresentative of your data if you have less than five data points.

To discuss these statistics, the following example will be used. The example shows 11 dissolved oxygen readings (mg/L) from six different sites.

SITES	1-7-00	2-4-00	3-3-00	4-7-00	5-5-00	6-2-00
SITE 1	7.7	6.4	6.8	7.1	7.3	7.1
SITE 2	6.6	6.3	8.4	7.2	6.5	8.6
SITE 3	7.2	5.6	6.8	6.8	7.2	5.4
SITE 4	7.2	10.0	9.4	6.4	8.0	7.0
SITE 5	4.6	5.4	6.0	5.0	5.2	5.6
SITE 6	4.0	6.8	7.4	7.1	7.4	7.0

Mean (Arithmetic Mean)

The mean, commonly referred to as the average, describes the typical value of a data set. It is obtained by adding all of the values in a specific data set and dividing by the total number of values within the set.

$$\text{Mean of Site 1 or } \mu = (7.7 + 6.4 + 6.8 + 7.1 + 7.3 + 7.1 + 7.1)/6 = 7.1$$

SITES	1-7-00	2-4-00	3-3-00	4-7-00	5-5-00	6-2-00	MEAN
SITE 1	7.7	6.4	6.8	7.1	7.3	7.1	7.1
SITE 2	6.6	6.3	8.4	7.2	6.5	8.6	7.3
SITE 3	7.2	5.6	6.8	6.8	7.2	5.4	6.5
SITE 4	7.2	10.0	9.4	6.4	8.0	7.0	8.0
SITE 5	4.6	5.4	6.0	5.0	5.2	5.6	5.3
SITE 6	4.0	6.8	7.4	7.1	7.4	7.0	6.6

However, a problem with means is that very high or low values in a data set will skew the mean and keep it from being a good representation of the majority of the data. For example, the Site 6 mean is 6.6, however, all of the data are above the mean except for one sample collected on 1-7-00. Therefore, the mean may not be representative of that data set.

Median

The median is the central value of a data set and is obtained by arranging the values within a data set from smallest to greatest and then locating the “middle” value. If the data set contains an even number of samples, like the dissolved oxygen example, the median is obtained by averaging the two “middle” numbers. For instance, let look at this number set:

5 5 6 7 7.5 20

The median would be 6.5 (The average of 6 & 7) and the mean would be 8.4. In this example, the median represents the data set better than the mean because it reduces the influence of one or two very high numbers within a data set.

Examine the differences between the mean and median with the dissolved oxygen readings in the following chart.

Sites	Mean	Median
SITE 1	7.1	7.1
SITE 2	7.3	6.9
SITE 3	6.5	6.8
SITE 4	8.0	7.6
SITE 5	5.3	5.3
SITE 6	6.6	7.1

Geometric Mean

The geometric mean is a common statistical parameter used when measuring bacteria counts. Like the median, geometric mean reduces the influence of very high or low numbers within a data set. To obtain the geometric mean you need to take the logarithm of each value; average the logs; and take the antilog of this average. Mathematically it is looks like this:

$$\text{Geometric mean (GM)} = \text{antilog} (\text{sum of log Y}) / (n)$$

Where, Y = each value and
n = number of values

Let's look at the following set of bacteria counts from a lake.

Count (Y)	Log Y
6	0.7781
2	0.3010
7	0.8451
400	2.6021
5	0.6990

$$\text{Sum of Log Y} = 5.225$$

$$\text{GM} = \text{antilog} (5.225)/(5) = 11$$

If you compare the geometric mean with the arithmetic mean (which is 84) there is a big difference between the two.

Range

The range describes the difference between the highest and lowest values within a data set and is calculated by subtracting the low value from the high value. A large range means there is a lot of variability within the data set. If the range is small, it indicates low variability within the data set

and also that the mean is probably a good representation of the data. In the dissolved oxygen example represented in the following chart, the range is the greatest at Site 4 (3.6) and the smallest at Site 1 (1.3).

SITES	HIGH	LOW	RANGE
SITE 1	7.7	6.4	1.3
SITE 2	8.6	6.3	2.3
SITE 3	7.2	5.4	1.8
SITE 4	10.0	6.4	3.6
SITE 5	6.0	4.6	1.4
SITE 6	7.4	4.0	3.4

Standard Deviation

The standard deviation of a data set describes the data set's variability around the mean. Similar to the range, a small standard deviation indicates little variability in the data and a large standard deviation indicates great variability in the data. The calculation of standard deviations is a little complicated. It requires finding the mean of the squares of the difference between each value and the mean and taking the square root of the result. Mathematically it looks like this:

$$SD = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

SD = Standard Deviation

- x = one value in your set of data
- x or μ = the mean or average of the data set
- n = the number of values (x) in the data set

One way of calculating the standard deviation for a group of data (SD) is as follows. Start by calculating the mean, (μ), of the data set. Subtract the mean from the value (x) and square that value (multiply it by itself) for each point in the data set giving you a $(x-\mu)^2$, value for each data point. Next, sum up all of those squared values and divide that result by the number of values in the data set minus 1. Lastly, find the square root of that number. That's the Standard Deviation of the data set. Luckily, scientific calculators and computer spreadsheets can perform this calculation for us.

The standard deviation is a useful tool for determining how "unusual" a measurement is within a group of measurements. If you make enough measurements of a "normal" population and plot them out on a graph, as below, pretty soon a pattern often described as a "bell curve" may

become evident. The convenience of this distribution of measurements is that it enables the data analyst to make predictions. The relationship that we are interested in for this example is the one between the mean, the standard deviation and any other measurement within the group. In a normal population of data values, 69% of the measurements should fall between the range of values described by the mean plus/minus one standard deviation 95% of the values should be between the mean plus/minus 2 standard deviations and almost all the values, 99.7% should be between the mean plus/minus 3 standard deviations.

An example of this may be more helpful; lets use the DO readings from site 6 in the example above.

SITES	1-7-00	2-4-00	3-3-00	4-7-00	5-5-00	6-2-00	MEAN	SD
SITE 6	4.0	6.8	7.4	7.1	7.4	7.0	6.6	1.2

The value for Jan. 7th looks a lot lower than the other values. How unusual is it? First set up the ranges described above with the mean and standard deviation To find the standard deviation range (SD Range), subtract one, two or three SD's from the mean (i.e. 6.6) for each range.

Site 6	SD Range	Percentage
Mean \pm 1 Standard Dev	5.4 to 7.8	69%
Mean \pm 2 Standard Dev's	4.2 to 9	95%
Mean \pm 3 Standard Dev's	3.0 to 10.2	99.7%

To make some sense of this, notice that all the measurements except one (4.0) fall between 5.4 and 7.8; near the mean. In a normal distribution curve, we'd that about 69% of the data will fall within this SD range and 31% of the data will normally fall outside this SD range. Similarly, we'd expect 95% of the data values to fall within \pm 2 standard deviation range and 99.7% of data values to fall within \pm 3 standard deviations. We'd expect to measure a value lower than 4.2 but higher than 3.0 only 5% of the time (100% - 95% = 5%), indicating that the value for Jan. 7th is pretty unusual and may be worth rechecking for error or unusual site conditions. If the value was less than 3, then it is extremely rare (100% - 99.7% = 0.3%) and something really unique is going on and is worth your attention.

The simplicity of this explanation will make your statistician cringe. As previously stated, this isn't a statistics manual. We just wanted to give you enough information to get you started and cause genuine concern and consternation for our mutual friend, the statistically gifted volunteer.

STEP 10: PRESENTING YOUR WATER QUALITY DATA

You must remember that volunteers are not volunteering their time just to collect numbers. They want to know what their data mean, especially in the big picture. The number one question you will hear from volunteers is “So how is the water quality?” Therefore, that means somewhere among the stacks of datasheets, stats, and printouts, you need to develop and write the water quality story. Graphs and tables of the data and stats will help you, but only if done properly.

WHAT DO YOU WANT TO FIND?

Again you are revisiting this question, “What do you want to find out with your data?” The answers should be written in your goals. So review them again. Moreover, is there any additional information that your audience wants to determine from the data? To help you...the following lists some common questions.

- Which sites did not meet water quality standards? How did they measure up against local and EPA water quality criteria?
- Do certain water quality indicators affect others? For instance, increases in water temperature may decrease DO levels or increases in nutrients may lower DO levels and increase algae growth.
- How do the seasons affect water quality? The rainy season may produce different results compared to the dry season.
- How does weather influence water quality? How does the impact of a storm affect water quality?
- What changes in a given water quality parameter occur over time?
- Are bacterial levels safe for swimming?
- Is there any correlation between visual observations and water quality parameters?
- Does the presence of specific land uses (sources) affect water quality?
- Are there trends in water quality that are causing episodic events?

SUMMARIZING WITH TABLES

Tables are an effective method to organize and summarize the data. Tables should be simple and easy to read. A clear title, legend and headings should describe the table at first glance. Tables of data provide only a list of numbers without consideration of external affects such as weather. Tables can be created to compare results at a site over time or compare two measurements like temperature and dissolved oxygen. Using symbols to easily interpret results is useful also (like the example below).

Water Quality from Five Sites within the Indian River Lagoon

STATION	SPR 99	SUM 99	FALL 99	WIN 00
IRL001	☆	☹	✓	☆
IRL002	☆	☆	☆	☆
IRL003	✓	✓	✓	✓
IRL004	✓	☹	☹	✓
IRL005	☆	✓	X	✓

Key to Symbols

GOOD = ☆ FAIR = ✓ BAD = ☹ MISSED SAMPLE = X

There are two key types of tables you will use: reference and summary tables. Reference tables display entire data sets that are used in graphs and summaries. Most of the time, these tables are very large with numerous pages and should be included as an appendix in a written report. Summary tables display statistical data such as average values of the different sites and are nice to include into a report or presentation.

DISCOVERING TRENDS WITH GRAPHS

Graphs are valuable tools that summarize and display trends in your water quality data. All graphs (except for the pie chart) contain scales on the two axes. The horizontal x-axis represents categories (like sampling sites) or a time period. The vertical axis or y-axis represents the values or levels of a parameter. So, what makes an effective graph?

- Make it clear. Avoid cluttering graphs with gridlines, fill patterns and other fancy computer graphic options.
- Limit the number of elements in your graph. For instance, a pie chart should not have more than six wedges and the number of bars on a graph should be kept to a minimum.
- Make it easy to interpret by labeling axes, reporting the units of measure, having the correct scale, creating a title that is simple yet informative and having a legend that explains each element of the graph.

Bar Graphs

Bar graphs use the height of simple columns to represent each data point. These graphs are easy to read and emphasize the importance of each data point. However, they do not show any trends within a data set. One of the most common uses of bar graphs is to compare levels of pollutants among one or more sites over time.

Line Graphs

Line graphs use points that are connected by lines to represent each value. These graphs are designed to show trends over time and emphasize the relationship among the data points. But be aware, the line connecting the points can be misleading if they do not contain enough data points to validate the trend.

Pie Charts

Pie charts compare categories within a data set by showing the proportional size of the categories to the whole. Pie charts are good at displaying proportions and percentages of the data and can be used to describe different land use, populations or pollutant loadings.

Combination Graphs

Combination graphs allow for two or more separate parameters to be viewed simultaneously by combining their graphs into one. These graphs are helpful because they allow the data from different data sets to be compared and successfully illustrate their relationship. However, care should be taken when using combination graphs because they can easily become cluttered.

PACKAGING YOUR RESULTS

Once you answer all of your questions by building your graphs and tables, now it is time to select the ones that tell the water quality monitoring story best and start writing. There are several ways to package your results. You can write a technical report, provide presentations, submit newspaper articles, create maps or present a poster, just to name a few. Below are some helpful hints that you should consider when developing and packaging your data.

- Know your audience's background in water quality. This will help you relay the results in an interesting format that will provide them the appropriate level of detail. Some audiences may only want the trends while others may want comparisons of results. Design the data presentation to meet the needs of the audience. Most audiences are just interested in the overall water quality – is it good or bad??
- Keep a clear message in your writing. Do not put every table and graph into it, just select the ones that support your message.

- Make sure your data, graphs and tables are accurate. If inaccurate data are released they will hurt your program's reputation.
- Compare your results with other studies.
- Use many photos and maps to enhance your message. A map of water quality results is a powerful and easily read method of interpreting your data for a variety of audiences. Easily color code maps to indicate good, moderate or poor water quality or a similar method of indicating water quality.

IN SUMMARY

At this point you have probably realized that Volunteer Monitoring involves a bit more than getting a bunch of Cub Scouts to dip water out of the creek. This is because the use of volunteers water monitoring is becoming a very important part of water quality data collection. If the data are to be comparable between organizations, acceptable to regulatory agencies and USEFUL, then they need to be appropriately collected. Through proper preparation, volunteer training and the implementation of a solid, approved QAPP, volunteer water quality monitoring programs have consistently gathered high quality data that are both credible and useful.

Because you're reading this manual, you likely have what it takes to organize a volunteer monitoring effort. It will require some work, but the potential rewards are great. To quote a bumper sticker, "*Think Globally, Act Locally*". On a global scale, there is little of greater importance than our water resources and you won't get much more local than your own watershed. You can make a difference and better yet, you can have fun and involve and educate other members of your community at the same time.



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WEBSITES

Conservation Technology Information Center (CTIC)
"Know Your Watershed" at <http://www.ctic.purdue.edu/KYW/>

Community Watershed Fund
<http://www.cwfund.org/index.html>

Education Network Corporation's Funding
<http://www.aenc.org/RESOURCES/EducResources-FS.html>

Florida Department of Environmental Protection
<http://www.dep.state.fl.us>

Foundation Center
<http://fdncenter.org/>

Hillsborough Watershed Atlas
<http://www.hillsborough.wateratlas.usf.edu/>

The Izaak Walton League of America
<http://www.iwla.org/>

National Water Quality Monitoring Councils
http://water.usgs.gov/wicp/acwi/monitoring/regional_councils.html

Seminole Watershed Atlas
<http://www.seminole.wateratlas.usf.edu/>

Southwest Florida Watershed Council
<http://www.swfwc.org/>

U.S. EPA *Catalog of Federal Fundraising Sources for Watershed Protection* (EPA 841-B-99-003)
(513) 489-8190 or (800) 490-9198
<http://www.EPA.gov/OWOW/watershed/wacademy/>.

U.S. EPA – STORET database
<http://www.EPA.gov/owow/monitoring/infosys.html>

U.S. EPA Watershed Information Network
<http://www.EPA.gov/win/>

U.S. Geological Survey (USGS)
1-800-USA-MAPS
<http://www.usgs.gov>

WATER QUALITY MONITORING SUPPLY CATALOGS

Carolina Biological Supply
<http://www.Carolina.com/>

Fisher Scientific Supply
<http://www.fishersci.com>

HACH Company
800-227-4224
<http://www.hach.com>

VWR Scientific Products
800-932-5000
<http://www.vwrsp.com>

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U.S. EPA. 1997. Volunteer Stream Monitoring: A Methods Manual. EPA# 841 B-97-003, Office of Water. U.S. EPA, Washington DC.

EXAMPLES OF FLORIDA VOLUNTEER WATER QUALITY MONITORING PROGRAMS

The Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network.

Charlotte Harbor National Estuary Program

4980 Bayline Drive, 4th Floor

N. Fort Myers, FL 33917

(239) 995-1777

www.charlotteharbornep.com

www.dep.state.fl.us/coastal/activities/research/waterquality.htm

To collect water quality data on a regular, technically sound basis and provide a framework for consistent testing, sampling, data analysis, and data presentation methods for monitoring programs in the region.

Florida LAKEWATCH

Dept. of Fisheries & Aquatic Sciences

University of Florida IFAS

7922 NW 71st Street

Gainesville, FL 32653-3071

1-800-525-3928 (1-800-LAKE WAT)

www.ifas.ufl.edu/~lakewatch/index.htm

Created by the Florida State Legislature in 1991, Florida LAKEWATCH was designed to enhance the level of scientific knowledge available about Florida's lakes, to help citizens and lake users understand and manage their lakes, and to develop an educated well-informed constituency.

Lee County Pondwatch

Lee County Hyacinth Control District

P.O. Box 60005

Ft. Myers, FL 33906

(941) 694-2174

Educate homeowners about issues and problems related to their ponds through active participation in pond monitoring.

The Marine Resources Council Indian River Lagoon Watch

Marine Resources Council

270 Paint Street

Rockledge, FL 32955

(321) 504-4500

www.mrcirl.org

The Marine Resource Council of East Florida's goals are to provide agencies involved in regulating the Indian River Lagoon with data of known quality for determining long-term seasonal and temporal trends in water quality.

St. Andrews Bay Sea Grass Monitoring Network

St. Andrews Bay Resource Management Association

P.O. Box 15028

Panama City, FL 32406

www.sabrma.org

To determine baseline information regarding seagrass coverage in St. Andrews Bay and West bay.

APPENDIX A

**THE SEBASTIAN H₂O GUARD
CITIZEN WATER MONITORING PROGRAM
SITE SURVEY FORM**

Date: ____/____/____

Name: _____ Site #: _____

Location of Site: _____

Latitude: ____° ____' ____" N Longitude: ____° ____' ____" W

Land Use within the Watershed (place a check):

- residential (single family multifamily)
- commercial
- industry and manufacturing
- agricultural (grazing crops)
- marine/ nautical industries
- other _____

Water Use within the Area (place a check):

- recreation
- drinking water supply
- industry
- flood control
- other _____

Land Formations in the Area (place a check):

- forest
- marsh
- seashore
- other _____

Bank or Shore (circle all that apply):

- soil clay litter sand rock gravel

Steepness of the Bank (circle one):

- 0-1 foot 1-5 feet 6-10 feet greater than 10 feet

Other Observations: _____

APPENDIX B

SECCHI DISK

By Linda Green
Program Coordinator of Rhode Island Watershed Watch

The Secchi disk is the basic tool of lake water quality monitors worldwide. It is always 8 inches (20 cm) in diameter and usually painted black and white. Secchi disks may be purchased for about \$25-\$30, but many volunteer monitoring groups make their own. A variety of materials can be used, including acrylic (see illustration), wood, or steel, or even aluminum pie tins. Rhode Islands Watershed Watch uses 1/8 inch steel, cut by a local machine shop and primed and painted with automotive paints.

In situations where there is significant water flow, the disk should be weighted to ensure that it goes straight down. Some monitors have used a brick or a sand-filled plastic jug for this purpose. Beverly DeAngelis of the NY/NJ Baykeeper program harvests used auto stereo speakers from a local junkyard and dismantles them to get the heavy circular magnet inside. She says the hardest part is drilling a hole in the center of the magnet and recommends a sturdy drill with an expendable bit.

A calibrated line is attached to the Secchi disk in order to measure the maximum depth at which it is visible. The type of line used is very important. Avoid cotton clothesline because it stretches when wet. Jeff Schloss, of the New Hampshire Lakes Lay Monitoring Program, suggests using nonstretching white plastic-coated wire-core clothesline; bend and straighten the line before you buy it to see if it will lie straight. Julie Rector of Washington's Citizen Lake Monitoring Project uses solid braid polyester lone, which she preshrinks by soaking it and then hanging it out to dry. Most programs, including Watershed Watch, use nylon line.

Mark standard intervals (in feet or meters) with an indelible marker. Julie Rector uses red for 5-foot intervals and black for 1-foot intervals. Knots may be used either instead of, or in addition to, the marker. Whatever type of line you use, be sure to check periodically to make sure the distances you've marked haven't changed due to shrinkage or stretching.

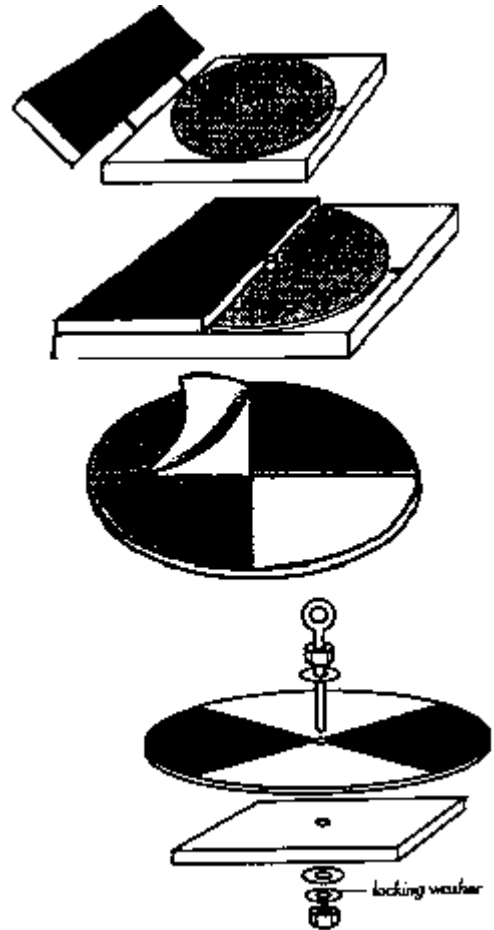
HOMEMADE ACRYLIC SECCHI DISKS

Julie Rector

Former coordinator of the Washington Citizen Lake Monitoring Project

From a plastic supply house, order 20-cm diameter, 1/4"-thick white opaque acrylic disks with 3/8" holes drilled in center. (Disks come with paper masking on both sides.)

1. Make a simple contraption from wood to hold the disk while scoring the paper. Upper hinged board serves as a knife guide. Bottom board has a dowel to center the disk and a mark for lining up first score mark.
2. After scoring paper, peel paper from opposing quadrants.
3. Rough up exposed acrylic with fine sandpaper and warm disk under bright lights. While disk is still warm, paint quadrants with flat black enamel paint. After second coat, peel off masking. Paint takes about 2 weeks to fully harden; if disk is used during the hardening period, treat it gently to prevent chipping.
4. To weight disk, use 1/4" steel cut to 5" x 5", with hole drilled in center (order from welding supply house). Paint steel plate to prevent rusting the locking washer.
5. Assemble disks with eyebolt (5/16" diameter). Use flat washers between disk and nut, and between steel plate and locking washer. Use 5/16" nuts at top of eyebolt, and to bolt steel plate onto disk.



APPENDIX C



THE H₂O GUARD
CITIZEN WATER MONITORING PROGRAM
DATA COLLECTION FORM

Collection Date: ____/____/____

Time of Day: ____:____ AM or PM

Name: _____

Site: _____

Site Number: _____

Water Surface (circle one):

calm ripple waves white caps

Weather (circle one):

cloudless partly cloudy overcast fog/haze sunny drizzle
intermittent rain rain other _____

Site Appearance (circle any that apply):

dead birds dead fish dead crabs oil slick plastic debris erosion
foam bubbles odors other: _____

Weekly Rainfall: ____ . ____ mm Air Temperature: ____ . ____ °C Water Temperature: ____ . ____ °C

Salinity: ____ . ____ ppt Dissolved Oxygen: ____ . ____ ppm

pH: reading _____ % T ____ . ____ pH units

Nitrates: time: ____ : ____ reading _____ % T ____ . ____ mg/l N

____ . ____ mg/l NO₃

Ammonia: time: ____ : ____ reading _____ % T ____ . ____ mg/l N

____ . ____ mg/l NH₃

Phosphates: time: ____ : ____ reading _____ % T ____ . ____ mg/l PO₄

Turbidity: reading _____ % T _____ FTU

Color: reading _____ % T _____ mg/l Pt

Total Sampling Time: _____ min.

Additional Comments: _____

SIGNATURE: _____